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MINING METHODS AND COSTS AT THE RIALTO MINE, NELLIE B DIVISION, AMERICAN ZINC, LEAD & SMELTING CO., OTTAWA COUNTY, OKLA.

By W. F. Netzeband

United States Department of the Interior — March 1958

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MINING METHODS AND COSTS AT THE RIALTO MINE, NELLIE B DIVISION, AMERICAN ZINC, LEAD & SMELTING CO., OTTAWA COUNTY, OKLA.

by

W. F. Netzeband[1/2]

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INTRODUCTION

This paper, which describes mining methods and practices at the Rialto zinc-lead mine, American Zinc, Lead & Smelting Co., in northeastern Oklahoma, is one of a series being prepared by the Bureau of Mines on mining methods, practices, and costs in various mining districts of the United States.

The Rialto mine is in the SE1/4 SW1/4 sec. 20 and the NW1/4 sec. 29, T. 29 N., R. 23 E., Ottawa County, Okla. (fig. 1). The 200-acre property is southwest of and adjacent to the town of Picher in the central part of the Picher field of the Tri-State zinc-lead mining district (fig. 2). Other mines of the company adjoin the Rialto on the east and south.

Zinc-lead ores have been mined almost continuously from the Rialto tract since 1916. The property was acquired by American Zinc, Lead & Smelting Co. late in 1951, and the mine was operated thereafter by the Nellie B Division of that company until the end of 1955, when it was subleased to the Residue Mining Co.

Mining operations in recent years have been confined largely to trimming or removing pillars and mining low-grade ore that was left in the roof and floor when the main ore body was mined. Mechanization enabled the company to reduce production costs and thereby mine the low-grade ore that had been bypassed previously.

ACKNOWLEDGMENTS

Acknowledgment is made to American Zinc, Lead & Smelting Co. for its cooperation and permission to publish the information in this paper. Special acknowledgment is due John J. Inman, district manager, and O. L. Green, general superintendent, for their cooperation in preparing data.

HISTORY

Much of the land in the northeast corner of Oklahoma, which includes the southwest part of the Tri-State zinc-lead mining district, was set aside by the Federal Government as a reservation for resettlement of several small tribes of Indians. The tribal lands were divided into 200-acre tracts in 1896, and each tribal member was allotted one of the tracts. The first record of ownership of the property now known as the Rialto mine was of allotment of the 200-acre tract to Sarah Cardin on September 26, 1896.

Zinc-lead ore was discovered and metal mining was begun in northeastern Oklahoma in 1891 near the town of Peoria, east of Spring River. Mining had spread westward to the vicinity of Quapaw by 1904 and to the area north of Miami within the next few years. The first shaft there was sunk in 1907. The first discovery of a large ore body in the main Picher field was made in 1914 by wildcat drilling.

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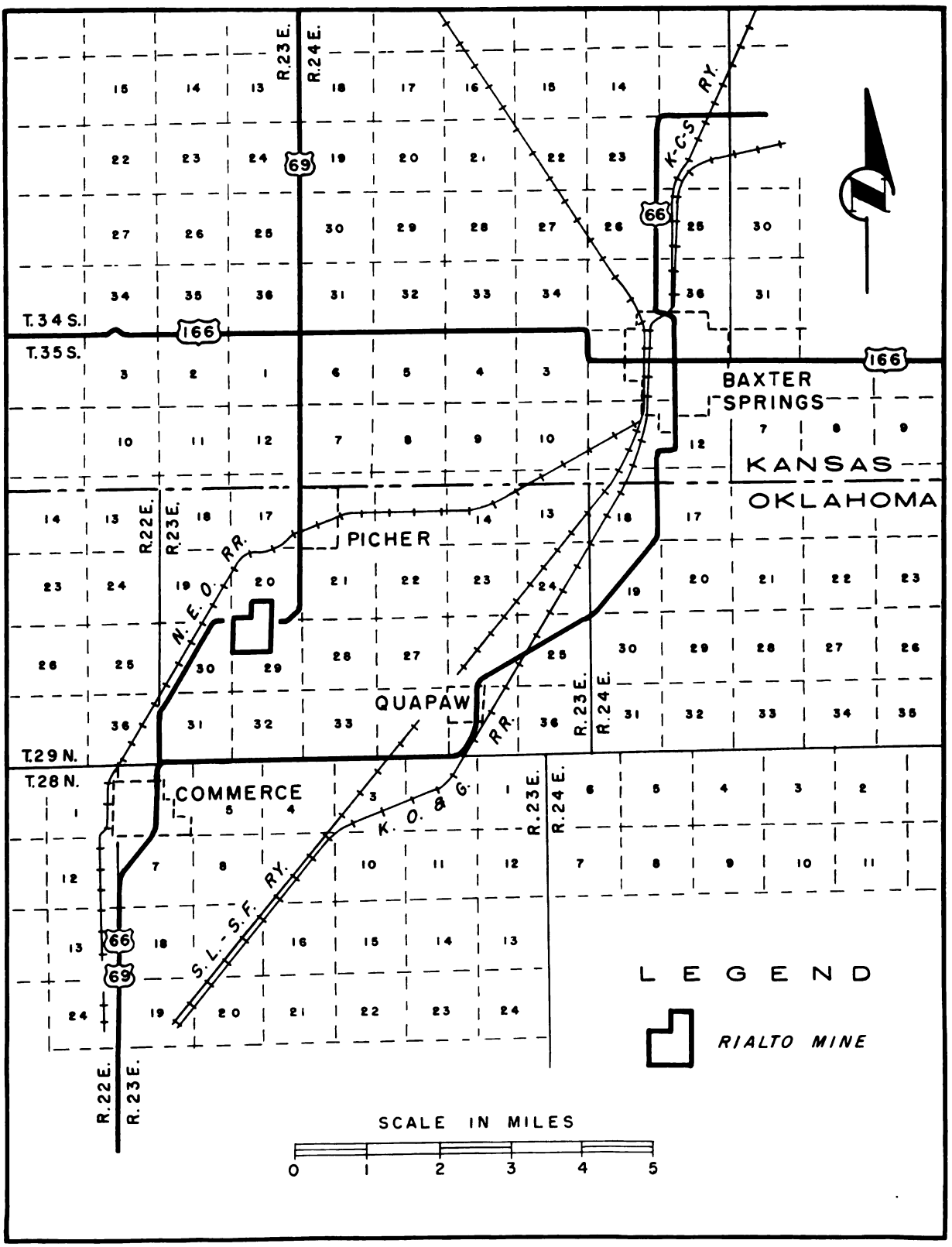

Figure 1. - Location map, Rialto mine, Ottawa County, Okla.

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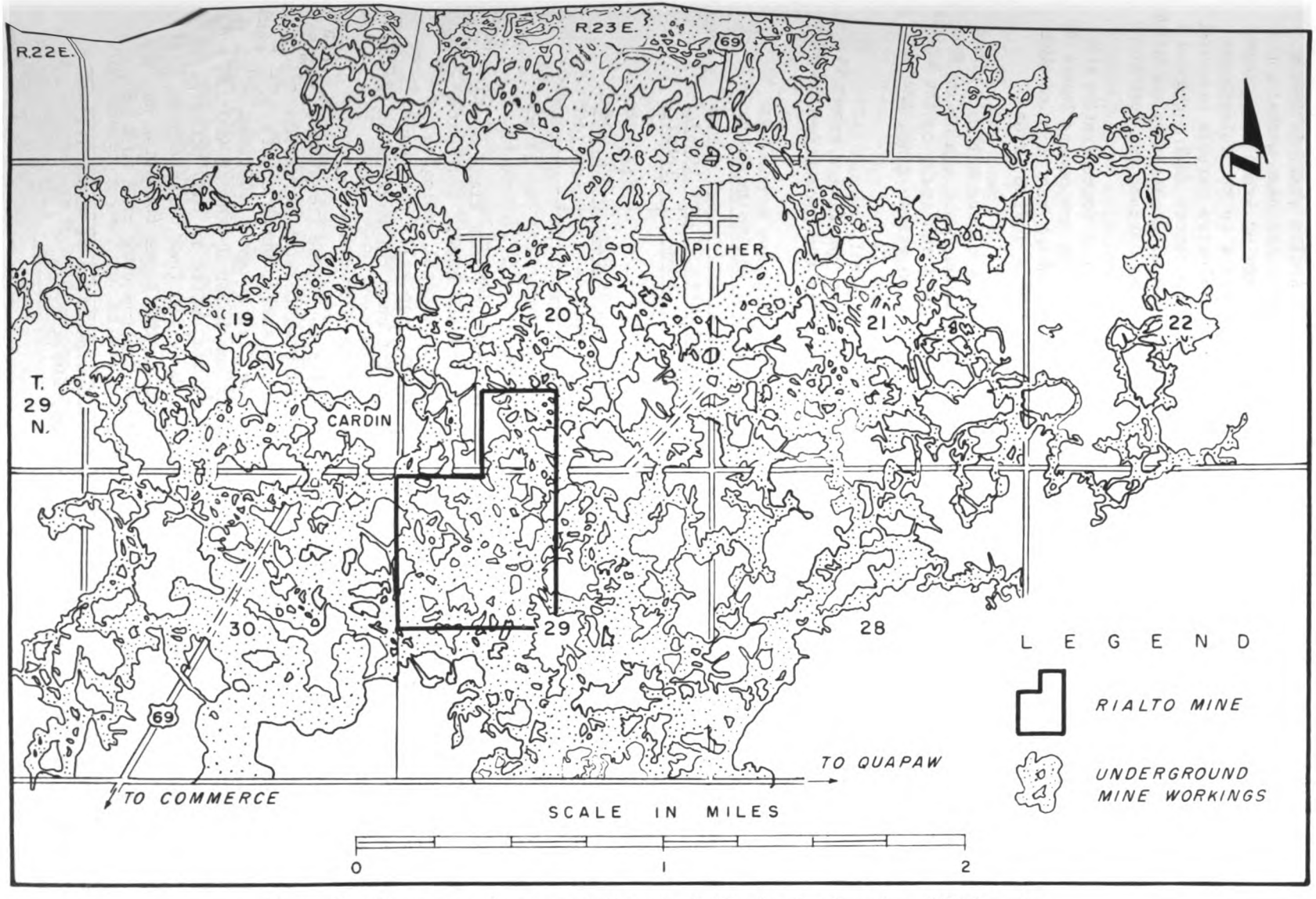

Figure 2. - Mines map of main part of Picher field, showing location of Rialto mine.

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Production records show that mining was begun on the Rialto tract in 1916 by the Bethel, Croesus, and Skelton mining companies. The mine has been worked continuously by one or more companies since then. The first mining lease recorded was executed on March 21, 1923, when Sarah Cardin leased the tract to the Tulsa-Quapaw Mining & Investment Co., which promptly subleased 20- and 40-acre parcels to several operating companies. The parcels were mined by numerous operators during the next 6 years; then, after lengthy litigation, the 200-acre tract was purchased by the Rialto Mining Corp. on November 7, 1929, from Sarah Cardin (Staton) Corbett and husband.

The fee and all assets on the Rialto property, including a concentration mill, were purchased by Helen L. Buchanan et al. early in 1948. The new owners leased the mine and mill on July 5, 1948, to the Nellie B Mining Co., which was then operating 2 mills on ores produced from about 1,000 acres of contiguous leased lands.

American Zinc, Lead & Smelting Co. purchased all assets of the Nellie B Mining Co. on October 1, 1951. The Rialto mine was worked continuously by the Nellie B Division from that date until December 31, 1955, when it was subleased to the Residue Mining Co. The ore was processed in the Barbara J mill of American Zinc, Lead & Smelting Co.

The recorded output of crude ore and concentrates from the Rialto tract is shown in table 1. Available records do not list separately the production of zinc and lead concentrates from 1916 through 1922.

TABLE 1. - Production of ore and concentrates, Rialto tract

Years	Crude ore (short tons)	Concentrates (short tons)		
		Zinc	Lead	Total
1916-22	1,400,000	-	-	112,194
1923-56	8,260,882	345,174	44,822	389,996
Total	9,660,882	-	-	502,190

DESCRIPTION OF DEPOSIT

The Tri-State zinc-lead mining district is on the northwest flank of the Ozark uplift, about 35 miles from the nearest outcrop of igneous rock. Sedimentary strata of shale, sandstone, limestone, chert, and dolomite of several geological periods overlie the granitic basement rocks. Logs of the few deep wells that have been drilled to the igneous rocks in the Tri-State district show thicknesses of sedimentary rocks ranging from 1,045 to 1,815 feet.

The zinc-lead ores occur mainly in the Mississippian Boone formation, which is successively overlain unconformably by the Mississippian Chester formation and the Pennsylvanian Cherokee-shale formation. The Cherokee shale, which covers the greater part of the Picher field, usually ranges from a few feet to about 200 feet in thickness in the main part of the field but reaches maximum known depths of 400 feet in certain structurally low areas. The Chester limestone, which is only occasionally ore-bearing, ranges in thickness from a trace to about 150 feet. Sixteen distinct mineralized beds of limestone, chert, and dolomite in the Boone formation have been recognized by Fowler and Lyden and designated from the top down as B to R beds.3/

3/ Fowler, George M., and Lyden, Joseph P., The Ore Deposits of the Tri-State District: Trans. AIME, vol. 102, 1932, pp. 206-251.

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Individual thicknesses of the lettered beds range from a trace to about 70 feet. Most of the ore produced in the Rialto mine has been mined from the G, H, K, M, O, P, and R beds, but in highly fractured areas the L and N beds also have been productive.

The ore bodies of the district are believed to be related to certain structural features and to have been formed as a result of disturbances that prepared the host rocks for replacement and deposition of the ore.4/ Increased porosity of the host rocks, either by solution or fracturing, presumably controlled much of the deposition.

The Rialto mine is on the flank of a structural dome about 1 mile east of the structurally low Miami trough.

The ore minerals are sphalerite and galena. The ratio of zinc to lead (metal) in the ores of the Tri-State district varies widely but has averaged about 4:1. The ratio in the Rialto ores has averaged about 6:1. Minor quantities of marcasite, pyrite, and chalcopyrite occur with the ore minerals. The gangue consists mainly of chert, jasperoid, dolomite, calcite, and shale. Limestone predominates in the unaltered beds. The ore minerals occur in masses cementing boulders of chert or jasperoid; crystal masses lining vugs or large cavities; fracture fillings in chert or calcite; lenses between thin beds of chert; and disseminated through the jasperoid, dolomite, or shale.

The ore bodies occur as narrow, sinuous runs, usually of the boulder-type ore; thin to moderately thick deposits of considerable lateral extent; and tabular deposits in thin-bedded cherts, usually referred to as sheet-ground or semi-sheet-ground ore bodies.

METHODS OF PROSPECTING AND EXPLORATION

Portable churn drills have been used almost exclusively in prospecting and exploring for ore from the surface. The relatively level land surface; the positions of the ore bodies, which are comparatively flat lying and usually at depths of less than 400 feet; and the nature and structure of the ore and enclosing rock have favored the use of this type of drill. Core drilling has been attempted at times but was found to be costly and unsatisfactory because of the many fractures and openings in the ore bodies and the difficulty in drilling through hard, abrasive chert and jasperiod.

Most of the prospect drilling in the district has been done under contract, at prices that ranged from less than $1 a foot in the early days to about $2 in recent years. Higher prices were charged for drilling deeper than 400 feet or where conditions of the rock required an abnormal quantity of casing. In some instances, where drilling conditions were expected to be severe or unpredictable, contracts were made on a per diem basis.

Locally, churn drilling to extend the known limits of an ore body or find isolated ore bodies in the vicinity of a mine was termed prospecting rather than development or exploration.

Copco drills mounted on air legs were used at times in the Rialto mine to probe for ore above, below, and adjacent to the main ore body. Long holes, usually

4/ Fowler, George M., Tri-State Geology: Eng. Min. Jour., vol. 144, No. 11, November 1943, pp. 73-79.

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somewhat less than 100 feet in depth, were drilled from underground stations at angles ranging from 3° to about 45° above the horizontal. Down holes were drilled occasionally, but difficulty in removing the cuttings satisfactorily limited their depth and effectiveness. Long-hole drilling costs ranged from $1 to $1.50 a foot.

METHODS OF DEVELOPMENT AND MINING

Development

Little development work is being done in the Picher field, as virtually all ore produced is mined from previously developed ore bodies.

All mines in the Picher field were developed from vertical shafts sunk from the surface to one or more mining levels. Virtually all shafts are 5 by 7 feet or 6 by 6 feet in cross section. The Rialto mine has 26 shafts, although only 5 are now equipped for hoisting. Three of these were used for hoisting ore in 1955 - shafts 2, 3, and 4 (fig. 3). A few shafts were capped with concrete slabs and later covered with mill tailing, but most of them were kept open and used for ventilating, pumping, or servicing the mine with electric cables and air and water lines.

Most of the Rialto shafts were sunk originally to depths ranging from about 180 feet to 240; 1 shaft (No. 5) reached a depth of 303 feet. The depths to various levels in the three shafts used for hoisting in 1955 are shown in table 2.

TABLE 2. - Depths to levels in hoisting shafts

Level	Depth of shaft below collar (feet)		
	No. 2	No. 3	No. 4
Upper	184	-	-
Haulage	233	221	230
Hoisting	283	237	272

Development and mining centered for many years in the main ore body, which was mostly in the M bed at a depth of about 220 to 230 feet. Numerous smaller, isolated ore bodies in the M bed were developed by driving 5- by 7-foot drifts (locally called "pull drifts") to them from the main ore body. Many of these drifts were enlarged later to 10 by 14 feet to make room for truck haulage and transferring loading machines.

Small, isolated ore bodies above the main ore zone in the K or G and H beds were developed by driving raises from the main level on inclines of 45° to 55°. These raises, 6 by 6 feet in cross section, were not timbered unless partitioned for ore chutes and manways.

Mining

The open-stope method of mining with natural-pillar support has been used in the Rialto mine, as in other mines of the Tri-State district, since operations were begun. Originally, 15 to 25 percent of the ore was left in the irregularly spaced pillars.

Virtually all ore obtained from the mine in recent years has been produced by mining low-grade ore from beds above and below the main ore body and by trimming or completely removing some of the pillars. The percentage of ore that ultimately will be left in the pillars is as yet undetermined.

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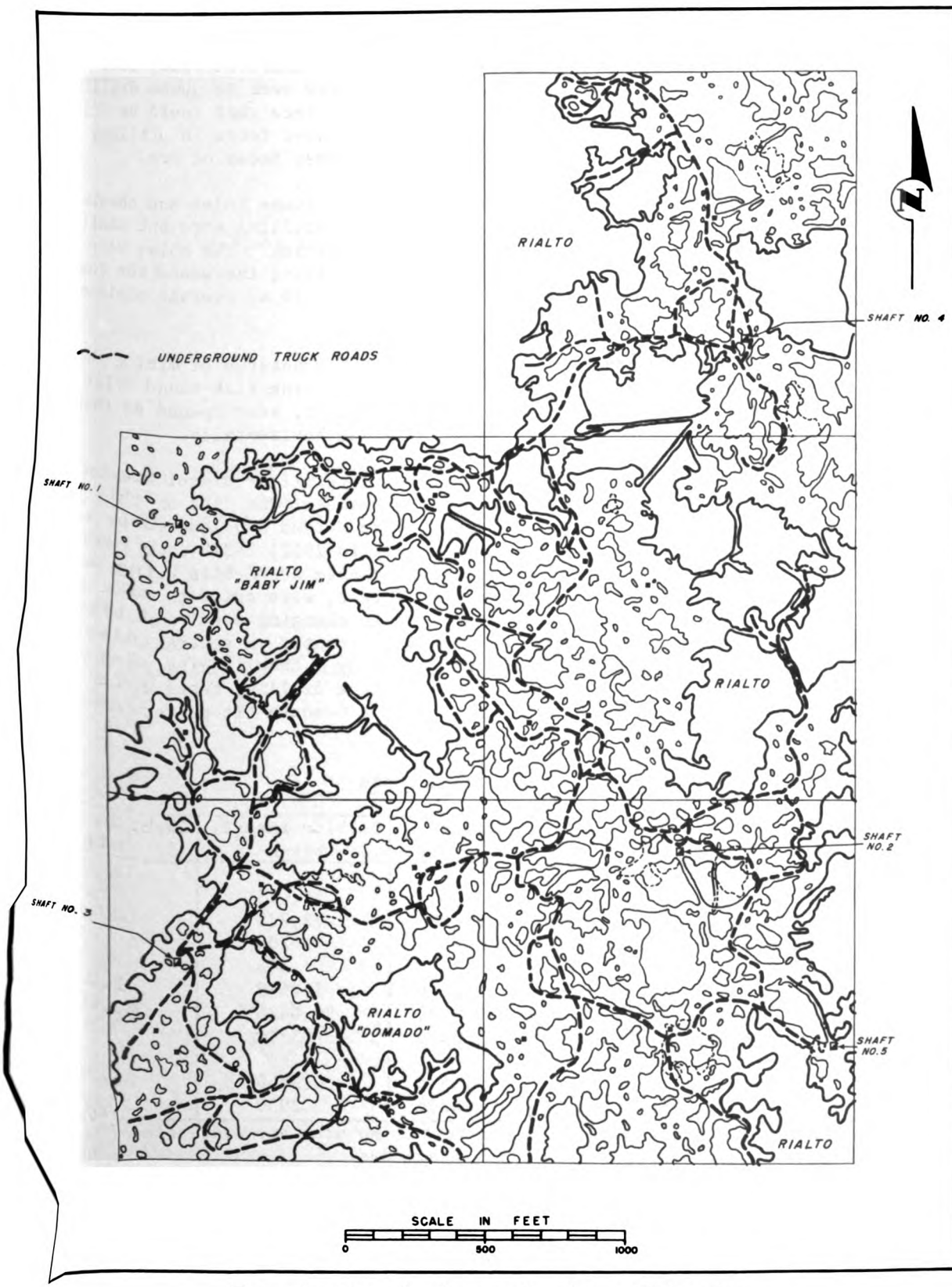

Figure 3. - Plan of underground workings, Rialto mine.

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Drilling

Drilling was done from posts and arms or tripods when American Zinc, Lead & Smelting Co. began operating the mine. The company changed over to jumbo drilling early in 1952. The use of jumbos increased the height of face that could be drilled in 1 operation from 12 feet to 20 or 25 feet. This increased range in drilling height resulted in fewer and larger breaks across the higher faces of ore.

The practice of drilling 18- to 20-foot splitter and stope holes and chambering them several times before final blasting was replaced by drilling more but shallower holes, 11 to 13 feet in depth, and blasting without chambering. The holes were drilled as a slab round (see fig. 4). This method of drilling increased the quantity of ore broken per machine shift from an average of 60 tons to an average minimum of 95 tons and a maximum of 150 tons.

Jumbos were used mainly in "taking up stope," which consisted of mining the ore in beds N, O, and P below the original floor of the mine. The slab-round drill holes in these faces of ore, which ranged up to 20 feet in height, were spaced so that the burden on each hole did not exceed 6 feet vertically and horizontally.

The first jumbo to be used was mounted on a D-4 Caterpillar diesel tractor and carried two I-R 505 drifters on 11-foot chain-drive sashes. The jibs on this jumbo, which were built and mounted in the company shop, were raised and lowered by an air hoist. Soon after this jumbo was put into use (early in 1952) 2-3/8-inch carbide-insert bits were substituted for the 2-5/8-inch detachable steel bits being used. The insert bits, with 2 lengths of steel, 11 and 15 feet, were tried to take full advantage of the long sash and reduce the time lost in changing steel and bits. The results were so encouraging that drilling jumbos were mounted on several diesel trucks. The truck-mounted jumbos were equipped with Joy hydraulic jibs, 8-foot aluminum sashes, and I-R D-35 drifters. Later, comparative drilling tests were run with another make of carbide-insert bits. The results of a 6-month bit-performance study are shown in table 3.

TABLE 3. - Drill-bit data

Item	Detachable steel bits	Carbide insert, bit A	Carbide insert, bit B
Number of rock drills	6	4	5
Total footage drilled	46,634	55,423	84,495
Ore broken ..... tons	60,980	72,272	107,848
Number of bits used	-	102	205
Footage drilled per bit	-	543	412
Ore broken per foot drilled ..... tons	1.3076	1.2679	1.2760
Bit cost per foot drilled	1/ $0.0280	$0.0426	$0.0518
Labor cost per foot drilled	.5335	.3314	.3126
Bit and labor cost:			
Per foot	.5615	.3740	.3644
Per ton	.4294	.2950	.2855

1/ Includes cost of reconditioning bits for reuse. No data are available on number of times bits were reused before being discarded.

The lower costs for labor per foot of drilling with A and B bits were expected because of the time saved in making fewer changes in steel and bits. The tests were made with only 1 size (2-3/8 inches) of A bit, whereas 3 sizes (2-1/2, 2-3/8, and 2-1/4 inches) of B bits were used; this may be why greater footage was drilled per bit by the former.

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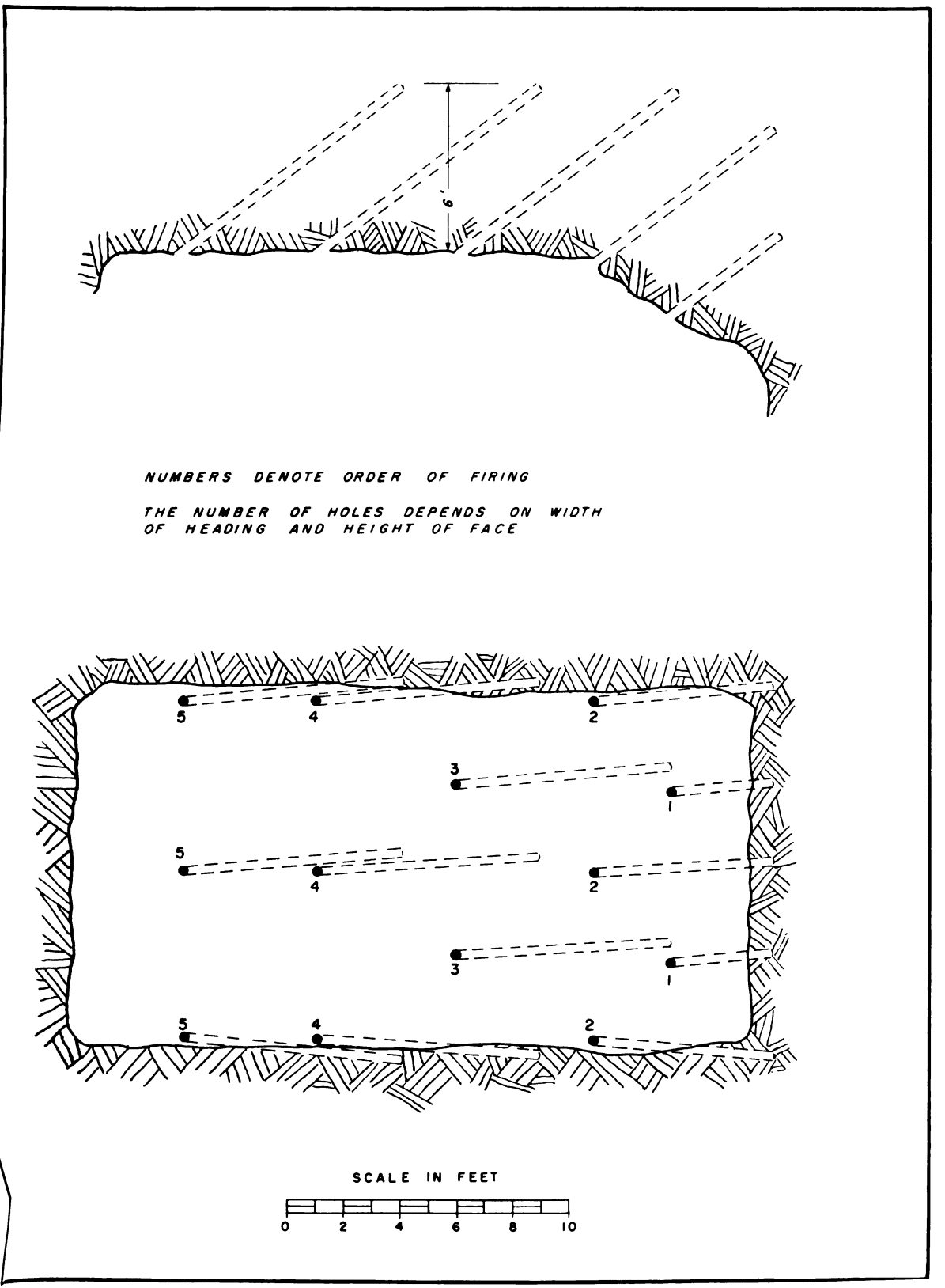

Figure 4. - Jumbo slab round.

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The source of a substantial part of the ore mined in recent years was the low-grade ore left in the roof during earlier mining. In some areas mineralization was continuous through the G, H, K, and L beds; in others the barren or sparsely mineralized beds directly over the M bed were thin enough to permit profitable mining of all beds through the K or G beds. A special drill tower was built in the company shop for mining this roof ore. The tower, which can be raised to a height of 40 feet, is mounted on a Caterpillar diesel No. 212 motor grader (fig. 5). The unit was stabilized for drilling and scaling by forcing the blade of the grader against the floor. The tower can be telescoped to 20 feet and lowered to a horizontal or lower position when being moved about the mine.

Air pressure at the drills was maintained at about 80 p.s.i. All drilling was done with 1-1/4-inch hollow-round, low-carbon drill steel, which was fabricated and reconditioned in a well-equipped shop on the surface near No. 2 hoisting shaft.

Blasting

The explosive used most for blasting in the early days was ammonia dynamite of 33-percent strength. Gelatin dynamite of 40-percent strength was used in wet ground and in confined areas where noxious fumes were not readily expelled. The latest practice in the Rialto mine was to use 30-percent semigelatin dynamite for all blasting. The explosive charges were fired with No. 6 caps and fuse. The quantity of semigelatin dynamite consumed ranged from 0.60 to 0.80 pound per ton of ore broken.

Owing to the semicleanup nature of much of the mining in late years, ore breaking produced many large boulders that required secondary blasting. These boulders were blockholed with light handheld drills and blasted at the end of the shift. No blasting on shift has been permitted since the Oklahoma Metal Mining Code went into effect some 30 years ago.

Loading

Loading equipment in the Rialto mine consisted of five Caterpillar HT4 Traxcavator front-end loaders and two 3-drum slusher hoists on crawler-mounted ramps. All ore hoisted in 1955 was loaded by front-end loaders.

Slusher hoists had been used mainly where pillars were being trimmed or removed and roof conditions were unsafe for men and equipment to work in the open for sustained periods. One of the slushers was used for a time in a small stope above the main level. The broken ore was slushed into an open raise and allowed to pile up on the haulage level below. Ore was loaded from this pile into trucks with one of the front-end loaders.

Performance data for the front-end loaders and unit costs of loading in 1955 are shown in tables 4 and 5, respectively.

TABLE 4. - Loading data, 1955

	Shaft			Total and average
	No. 2	No. 3	No. 4	
Ore loaded[1/] ..... tons	129,320	138,220	92,270	359,810
Loader shifts worked	546	554	307	1,407
Ore loaded per loader shift ... tons	237	250	301	255.7

1/ Based on truck factors and adjusted to total tonnage hoisted.

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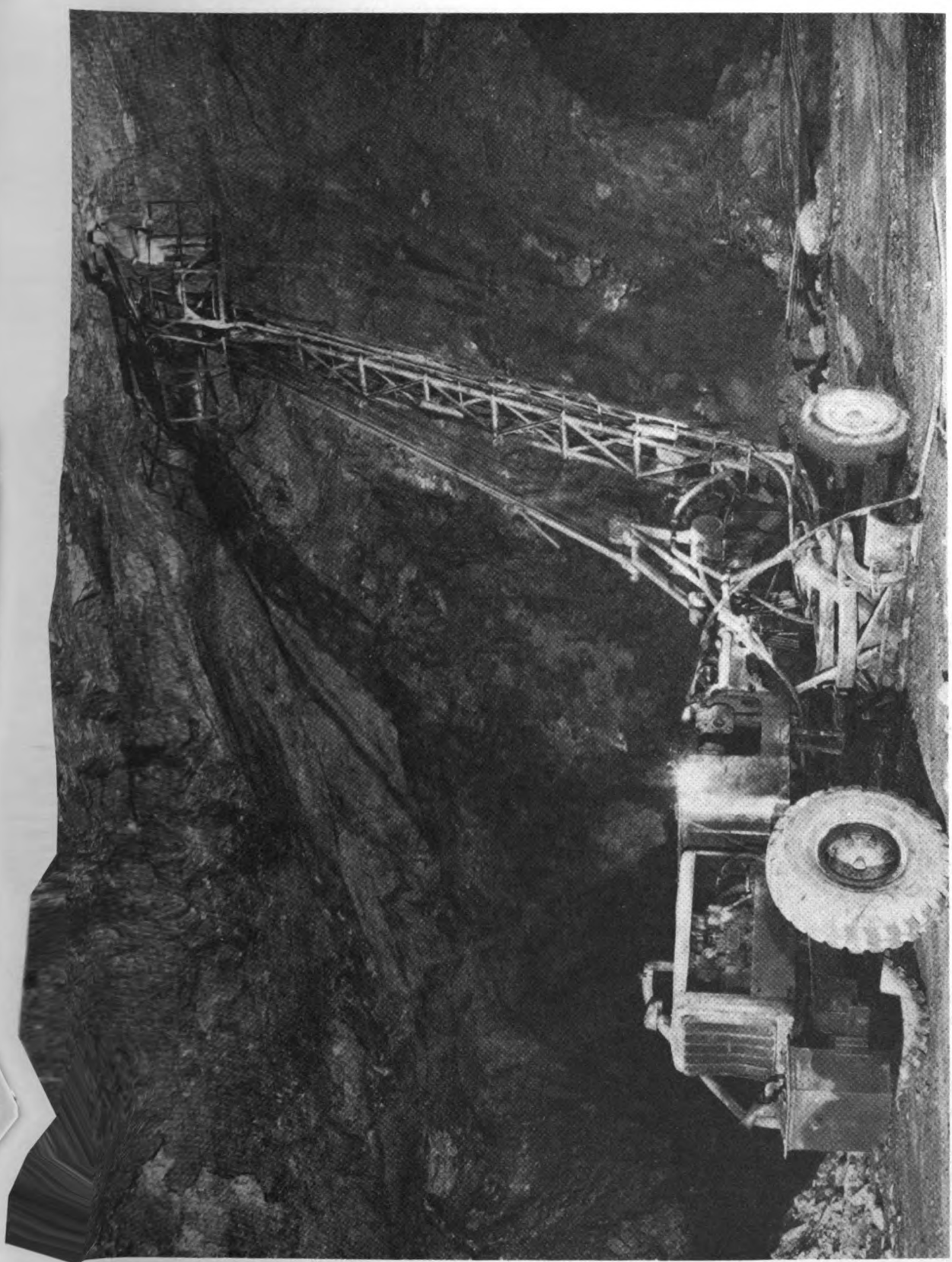

Figure 5. - Drill tower.

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TABLE 5. - Underground-loading costs, 1955

Item	Cost per ton
Operating labor	$0.0729
Maintenance labor	.0367
Operating supplies	.0082
Maintenance and repair supplies	.1000
Total	0.2178

The output per loader per shift was usually limited to less than capacity by transportation conditions or requirements. At times, when a loader was idled for repairs and only 1 loader was available for servicing all trucks in a section of the mine, the loading rate of that machine increased to as much as 450 tons per 8-hour shift.

Underground Transportation

Ore was transported underground to the hoisting shafts with diesel-powered standard dump trucks and semitrailer bottom-dump trucks. The standard dump trucks had carrying capacities of about 5 short tons of ore, and the semitrailer trucks 5.5 tons. The dump trucks were equipped with standard hydraulic lifts and airbrakes.

The two types of trucks were used in the Rialto mine because of differences in hauling and dumping conditions, which varied with the sources of ore mined. Dump trucks were used for hauling to No. 3 shaft, mainly because they were better suited to handling and dumping the coarse ore broken in that part of the mine. Stoping in the sheet-ground beds N and O and mining the L-bed roof ore there produced many boulders that required further breaking before being loaded into cans for hoisting. This bouldery ore was unloaded readily from the dump trucks onto a flat grizzly of heavy steel rails, which was installed at road level over the transfer hopper, as shown in figure 6. The oversize was then sledged through the grizzly by a crew of 1 to 3 men. Dump trucks were better suited also to hauling ore up the steep grades leading from the sheet-ground stopes to the haulage level in the area served by No. 3 shaft. The semitrailer trucks were prone to jackknife on the steep grades.

The semitrailer trucks were well suited to hauling ore from the areas served by Nos. 2 and 4 shafts. Much of the ore hauled to these shafts was mined from large pillars in the M bed and from the overlying thin-bedded G, H, or K beds. Good fragmentation was obtained, and most of the ore was transported over moderate grades on the main level.

The transfer hopper at No. 2 shaft was built to hold about 200 tons of ore. The grizzly was installed below road level, as shown in figure 7. The dumping slot was designed for unloading ore from the semitrailer trucks but could also accommodate the dump trucks. No grizzly was used at No. 4 shaft; otherwise, the shaft and hopper layout was similar to that of No. 2 shaft.

During 1955, the average truck made 28 round trips per shift, hauling about 140 tons of ore a shift. The average distance of each round trip was 2,800 feet, and the longest haul to a hoisting shaft 2,500 feet.

Underground roads were built with mill tailing, which was dumped into the mine through various shafts, loaded into trucks, and spread along the haulageways. Front-end loaders were used for loading the trucks and grading the roads. The tailing selected for roadbuilding contained enough fines to insure compaction of the material

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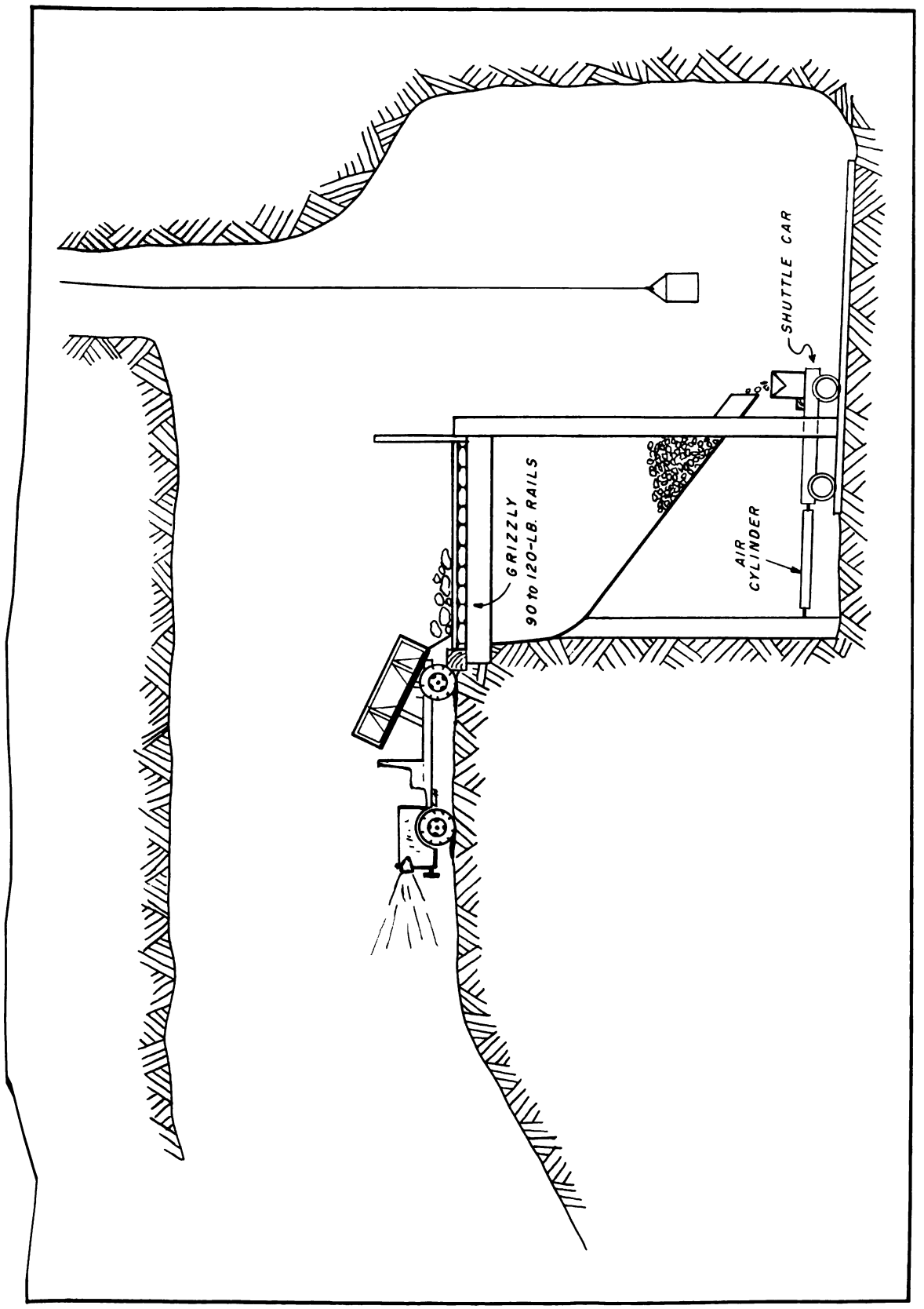

Figure 6. - Underground hopper layout, No. 3 shaft (not to scale).

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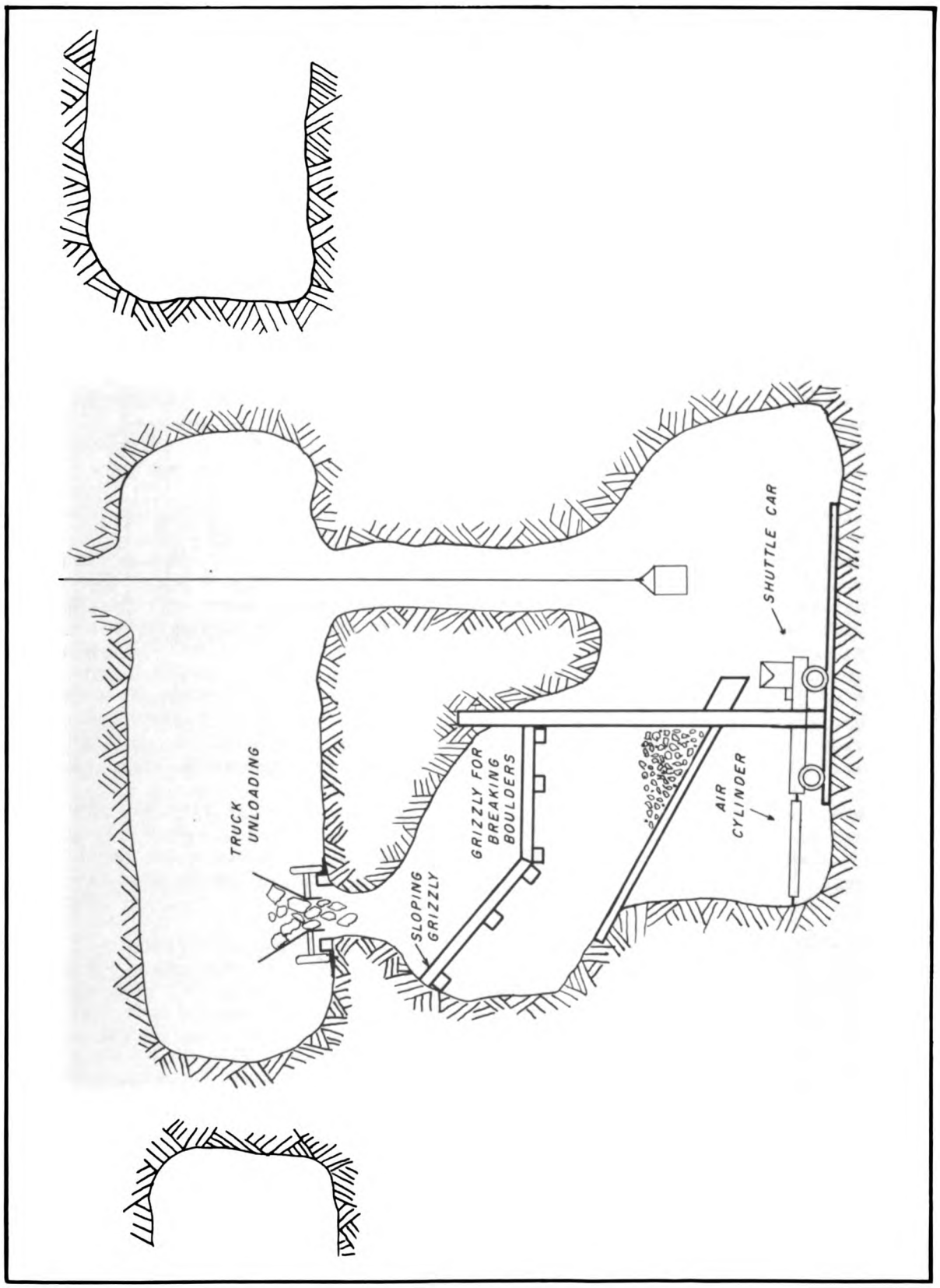

Figure 7. - Underground hopper layout, No. 2 shaft (not to scale).

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into a hard, durable roadbed. The roads were sprinkled, as required, to eliminate dust, but the mine air was usually humid enough to keep the roads damp.

Unit costs of transporting ore underground in 1955 are shown in table 6.

TABLE 6. - Underground-transportation costs, 1955

Item	Cost per ton
Operating labor	$0.0897
Maintenance labor	.0366
Operating supplies	.0182
Maintenance and repair supplies	.0787
Total	.2232

Hoisting

The hoisting methods used at the Rialto mine, although modified in some details, have been virtually standard in the Tri-State district for many years. Ore was hoisted with single-drum, geared hoists, driven by 75- or 112-horsepower electric motors. Each hoist was installed in a derrick, 40 to 60 feet above the collar of the shaft, in such a position that the hoistman had full view of the bottom of the shaft.

Ore was hoisted in cans (buckets), 33 inches in diameter and 34 inches in depth. The average capacity of a can was about 1,200 pounds of low-grade ore. Shuttle cars were used at the hoisting shafts to move the cans from the loading positions at the transfer hoppers to the hoisting positions in the shafts. The shuttle car was developed by The Eagle-Picher Co., but those used at the Rialto mine were built in the shops of American Zinc, Lead & Smelting Co. and tailored to the layout of each shaft. The design and details of the shuttle car and the air ram that moves it are shown in figures 8 and 9. The sequence of hoisting and shuttling is shown in figure 10.

A hoisting crew consisted of a hoistman, hooker, and hopperman. The duty of the hooker was to swing the descending empty can and land it on the shuttle car, disengage the cable hook from the empty can, and attach the hook to the loaded can for hoisting. The hopperman, meanwhile, filled the can from the transfer hopper.

The normal rope speed when ore was being hoisted was 1,000 to 1,200 feet per minute; this was reduced to not over 600 feet per minute while men were being raised or lowered. The daily unit output of ore from the 3 shafts was 375 to 425 tons.

The hoisting cables were 5/8-inch, 7 by 18, nonspin, steel-wire ropes. They were replaced after hoisting 40,000 tons unless daily inspection indicated failure before this tonnage was reached.

Auxiliary Operations

The surface plant included a blacksmith shop and compressor plant at No. 2 shaft and a well-equipped machine shop near the main mine office, about a quarter of a mile northwest of No. 2 shaft. A machinist, an electrician, and 1 to 3 welders were employed for maintenance and repairs and to build new equipment. All drilling equipment was serviced in the blacksmith shop.

The underground loading and transportation equipment was serviced in an underground shop near No. 2 shaft by a crew of 3 mechanics and 1 welder.

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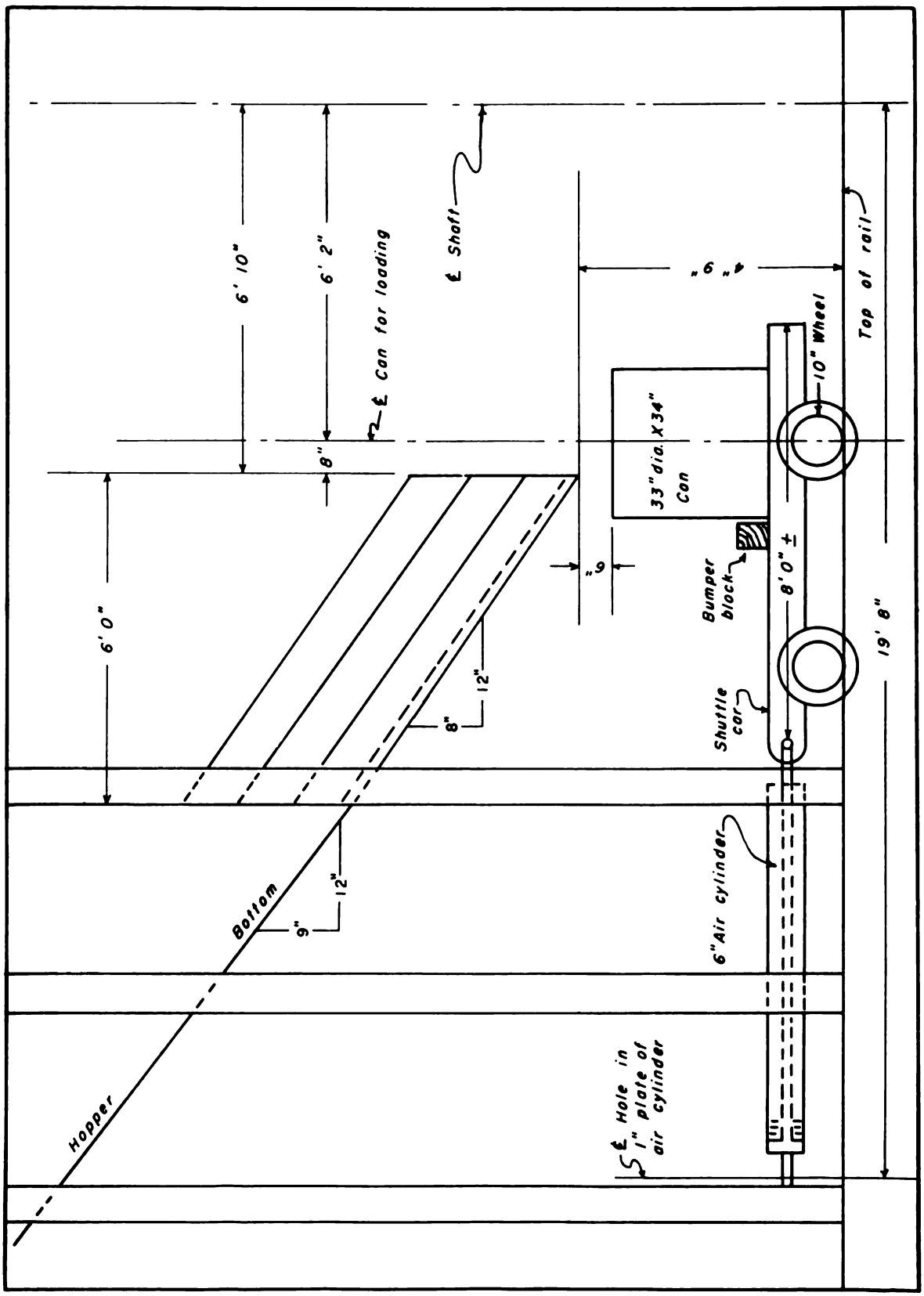

Figure 8. - Layout for shuttle car.

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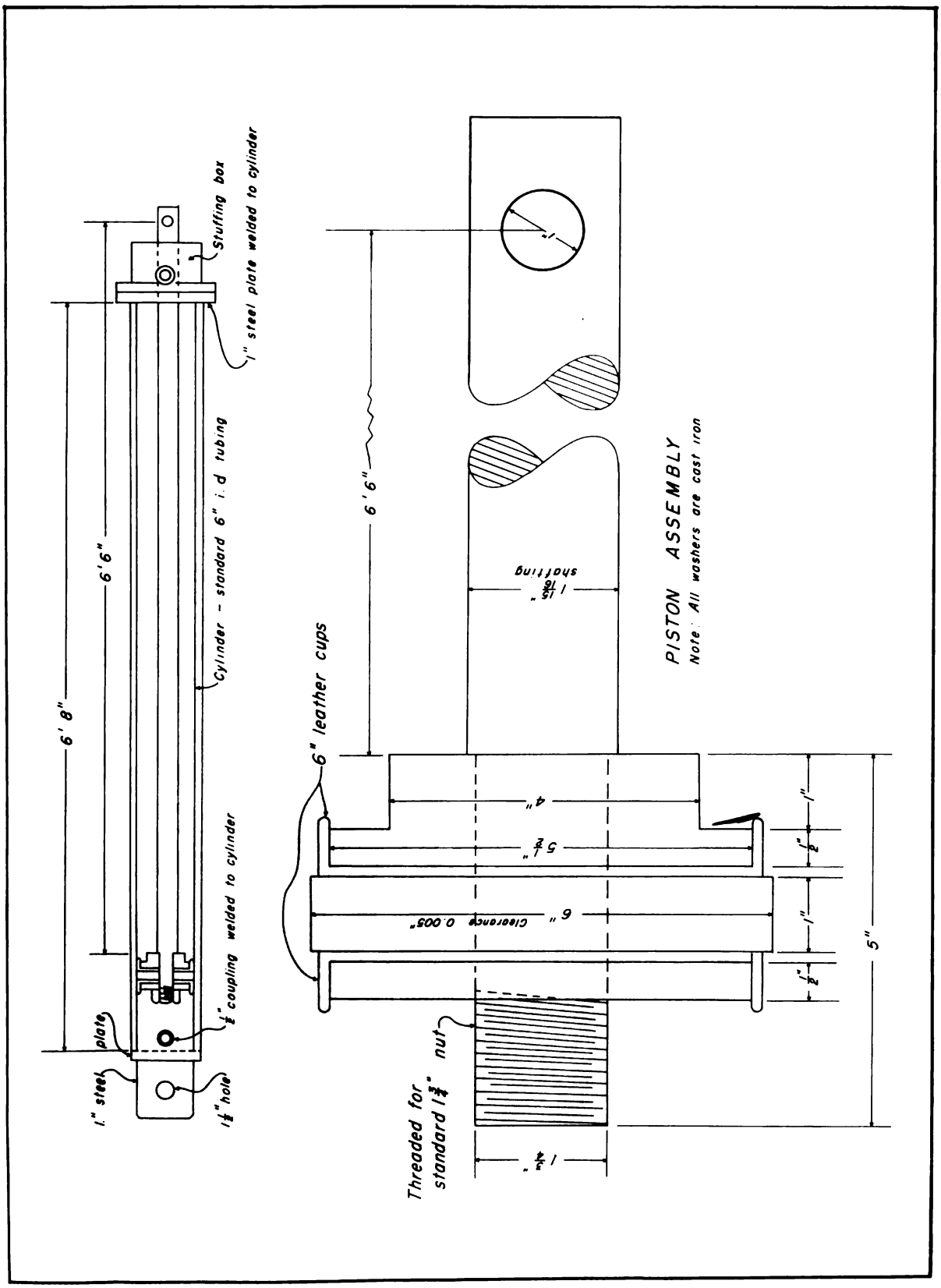

Figure 9. - Air ram for shuttle car.

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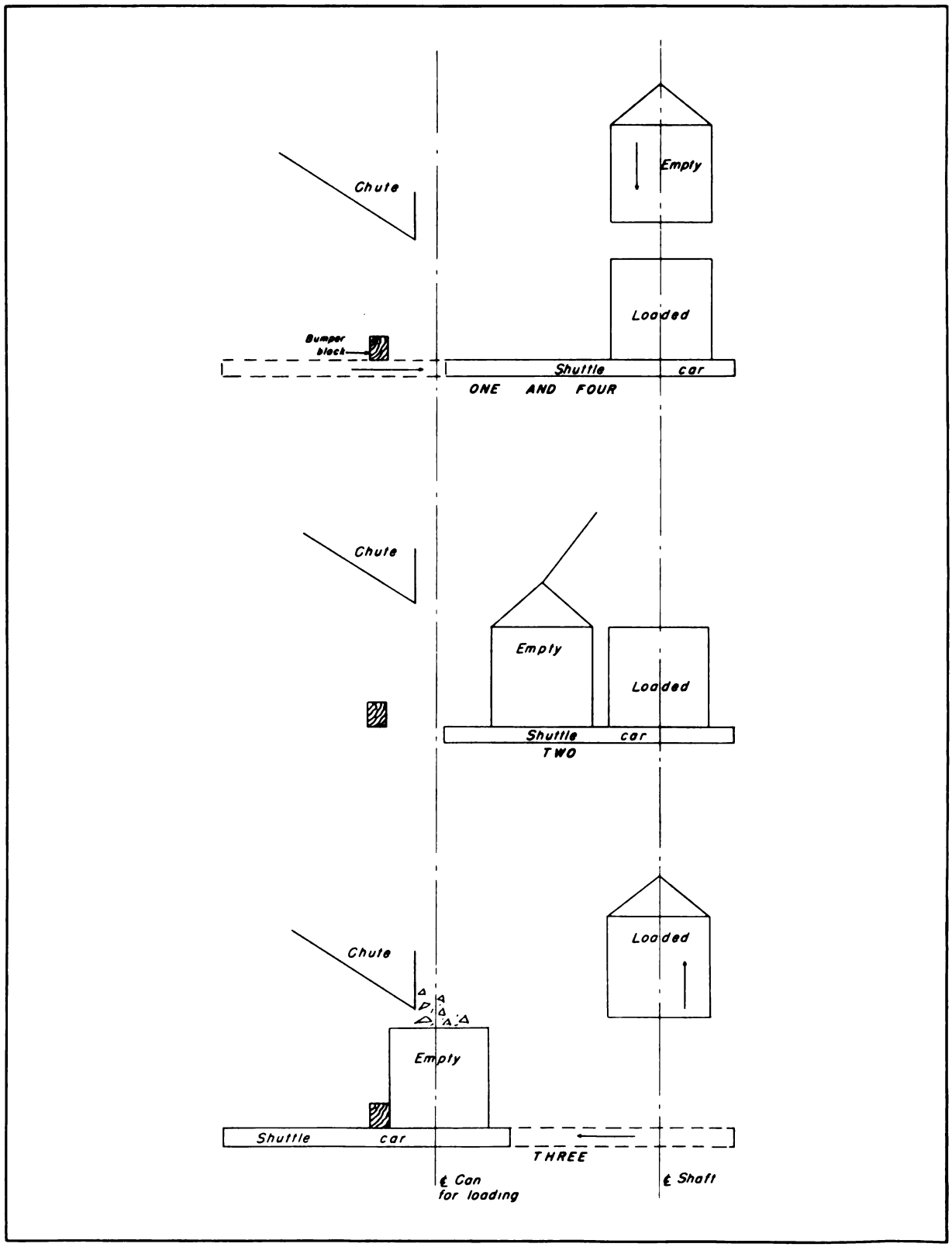

Figure 10. - Sequence of loading and hoisting, using shuttle car, Rialto mine.

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The compressor plant consisted of 4 compressors with a combined capacity of 4,000 cubic feet of air per minute at a pressure of 110 pounds per square inch. Compressed air for the Rialto and adjoining mines of the company was supplied by this plant.

Equipment

The principal items of equipment used underground at the Rialto mine are listed in table 7.

TABLE 7. - Underground equipment

Item	Number in use	Number in reserve
Crawler-mounted jumbo (two 4-inch drifters)	1	-
Truck-mounted jumbo (one 3-1/2-inch drifter)	5	-
Forty-foot grader-mounted drill tower (one 3-1/2-inch drifter)	1	-
Dump trucks (5-ton capacity)	3	1
Semitrailer trucks (5-1/2-ton capacity)	6	2
HT4 Traxcavator loaders	5	-
Three-drum slusher hoists	-	2
Flat-bed truck	1	-
Personnel car	1	-
Peerless deep-well pumps (10-inch)	2	-
Triplex pump (3-inch)	1	-

PRODUCTION RATE AND TENOR OF ORE

The total output of crude ore from the Rialto mine in 1955 was 359,811 short tons. The mine was worked 1 shift a day, 6 days a week, and produced ore at an average rate of 1,157 tons per day. The tenor of the ore, in terms of mill recovery of concentrates from the crude ore, averaged 2.73 percent for zinc and 0.21 percent for lead (based on 60-percent zinc content and 80-percent lead content of the zinc and lead concentrate, respectively). The combined recovery in 1955 (2.94 percent) represents a substantial drop in grade of ore from that mined in the early years. In comparison, the average combined recovery of concentrates during the period 1916-22 was about 8 percent, and the average from the time operations were begun to the end of 1956 was about 5 percent.

VENTILATION

The many open shafts in the Rialto and adjoining mines provided adequate natural ventilation throughout most of the mine workings. During severe winter weather, ice formations in the shafts and on walls and roofs near the shafts, and frozen air and water lines caused occasional hazards and operating problems; however, free circulation of air created a pleasant climate underground most of the time.

Small isolated stopes at the ends of long pull drifts usually required forced ventilation. Small multiblade blowers, driven by 2- to 5-horsepower electric motors, were used to force air from the surface through drill holes into the stopes. These blowers were used occasionally as exhaust fans.

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MINE DRAINAGE

Mine drainage has become a minor problem and item of expense, especially during the past 5 years of drought in the region. Water was pumped through churn-drill holes from two locations in the Rialto mine. Two 10-inch Peerless deep-well pumps were installed at No. 2 shaft and a 3-inch triplex pump in the southwest part of the mine. The capacity of each of the deep-well pumps was 800 gallons per minute and that of the triplex pump about 250 gallons per minute. The pumps were operated 4 to 8 hours a day, depending on the inflow of water to the sumps.

WAGE AND BONUS SYSTEM

Wages paid to the mine crew were based primarily on established hourly rates. In addition to the set wage, each man engaged in production participated in an incentive bonus, which was paid for production above a set minimum for each piece of equipment. The wage rates and incentive-bonus rates for the various classifications of labor in 1955 are shown in tables 8 and 9, respectively.

TABLE 8. - Labor classification and wage rates, 1955

	Number	Hourly wage rate 1/
Foreman	1	Salary
Shovel bosses	2	Do.
Machinemen	19	$1.505
Machine helpers	4	1.415
Roof trimmers	3	1.505
Loader operators	5	1.505
Truckdrivers	7	1.505
Hoistmen	3	1.505
Hookers	4	1.505
Screenmen	8	1.455
Hoppermen	4	1.415
Roustabouts	2	1.415

1/ Hourly rates were based on a 40-hour week. Actual rates paid for working the full 48-hour week were 52/48 of the rates listed.

TABLE 9. - Incentive-bonus rates, 1955

Classification	Bonus per can	For output in excess of -
Machinemen	$0.03	600 cans per week.
Machine helpers	.02	Do.
Loader operators	.01	1,000 cans per week.
Truckdrivers	.01	800 cans per week.
Hoistmen	.01	500 cans per day.
Hookers	.01	Do.
Hoppermen	.01	Do.

SAFETY AND HEALTH

Many regular functions of a safety department were delegated to the engineering department, as the company did not maintain a separate safety organization in the Tri-State district. Monthly inspections of mines and mills were made by one of the

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engineers in company with an inspector of the insurance company that carried the workmen's compensation insurance. The engineering department was responsible for seeing that the recommendations of the inspector were carried out. The engineers also kept statistics on all accidents and made appropriate suggestions for accident prevention.

The exhausts of all diesel engines used underground were equipped with company-built scrubbers to prevent pollution of the air by noxious exhaust gases. The standard scrubbers (fig. 11) were 24 inches in length and height and 12 inches in width. A similar but smaller scrubber was installed on the jeep used by the foremen. Data pertinent to constructing and operating a scrubber of this type are listed below:

1. It is important that the scrubber be so constructed and operated that a minimum of back pressure is developed within the unit.

2. The exhaust intake should be constructed of 2-1/2-inch o.d. tubing, long enough to contain a 1-1/2-inch check valve, which will prevent suction or splashing of water into the motor. A 2-1/2-inch i.d. heavy-duty, flexible armored hose should be used to connect the motor and scrubber.

3. The exhaust outlet from the scrubber should be at least 3 inches in diameter. It can be built into the top or side of the scrubber above the calcite screen.

4. The hole for refilling the scrubber with water should be just above or at the level of the calcite screen. The water level should be kept at the level of the calcite screen, never above it.

5. The drain plug in the bottom of the scrubber should be at least 2 inches in diameter so that water and sludge can be drained rapidly.

6. The pipes on the intake side of the baffle should be about 1-1/4 inches in diameter (pipes as small as 3/4 inch in diameter would allow excessive back pressure), about 1 inch apart, and should extend to within 2 inches of the bottom of the scrubber - the same distance as the baffle.

7. Both screens should be of 3/8-inch round-hole screen jacket and supported by angle-iron brackets welded to the side wall and baffle.

8. The lower screen should be covered with 4 to 5 pounds of No. 28 or 30 scrap-copper wire. Heavy wire should not be used, because it does not have enough exposed surface for the reaction desired with the exhaust gases.

9. The upper screen should be covered with a single layer of 1-inch fragments of calcite. Smaller fragments reduce the voids and tend to build up back pressure.

10. The scrubber should be refilled with water each morning and noon and should be drained and flushed at the end of each working day.

MINING COSTS

Unit costs per ton of ore produced at the Rialto mine in 1955, the last year in which the mine was worked by American Zinc, Lead & Smelting Co., are shown in tables 10 and 11.

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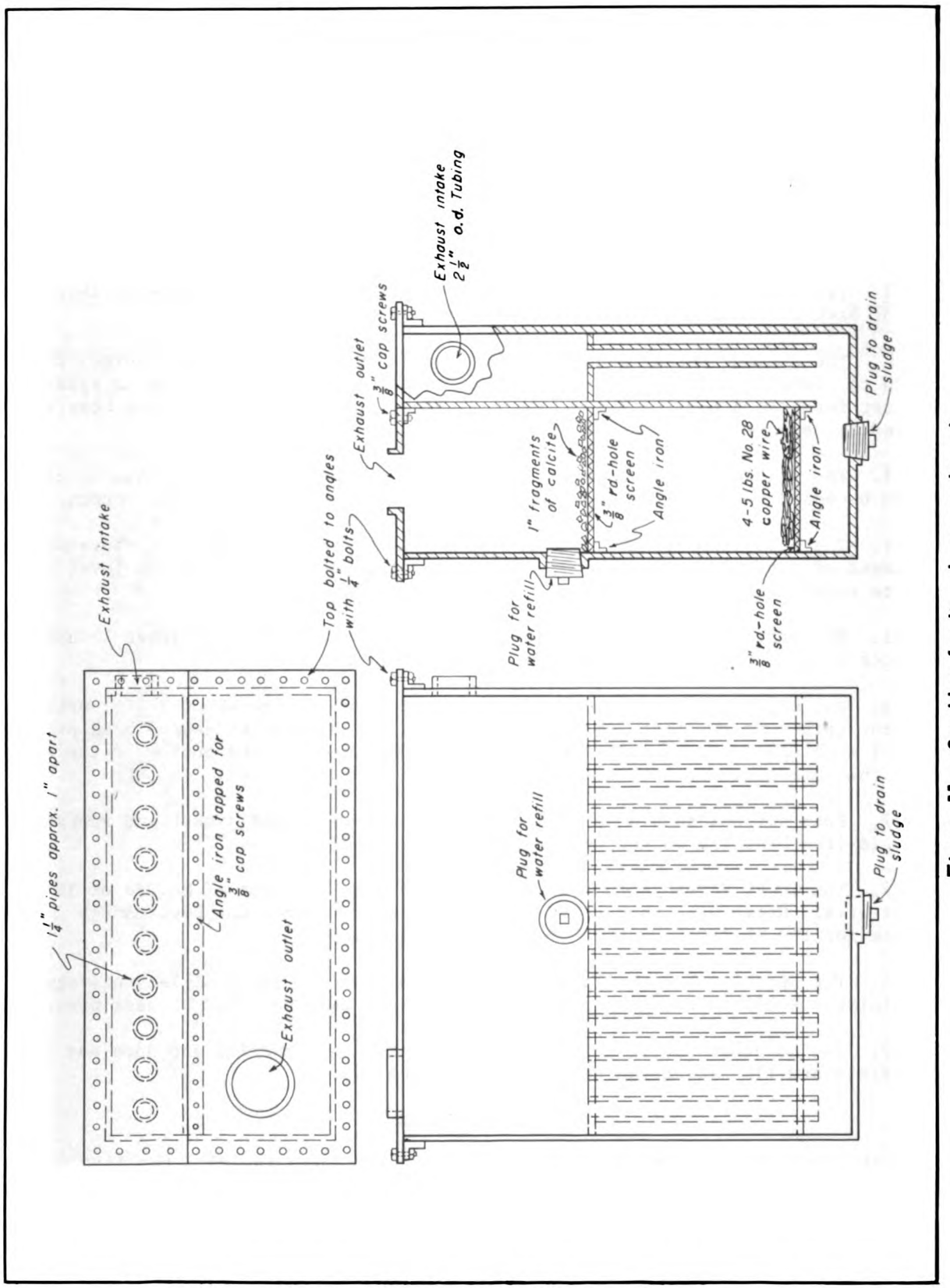

Figure 11. - Scrubber for diesel-powered truck.

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TABLE 10. - Summary of underground costs, 1955

Name of mine Rialto
Tons of ore hoisted 359,811
Mining method Open stopes with pillar support

	Underground costs per ton of ore hoisted						
	Labor	Super-vision	Compressed-air drills and steel	Power	Explo-sives	Other supplies	Total
Mining	$0.456	$0.047	$0.120	-	$0.154	$0.112	$0.889
Transportation	.276	-	-	$0.035	-	.124	.435
General expense	.140	-	-	.018	-	.011	.169
Surface expense (directly applicable to underground operation)	.186	-	-	.049	-	.028	.263
Total	1.058	.047	.120	.102	.154	.275	1.756

TABLE 11. - Summary of costs in units of labor, power, and supplies, 1955

Name of mine Rialto
Tons of ore mined and hoisted 359,811
Mining method Open stopes with pillar support

	Mining
A. Labor (man-hours per ton):	
Breaking (drilling, blasting, trimming)	0.159
Loading	.032
Haulage and hoisting	.096
Supervision	.021
General (includes surface labor)	.225
Total	.533
Average tons per man-shift:	
Underground	16.27
Surface	192.82
Total	15.00
Labor, percent of total cost	62.93
B. Power and supplies:	
Explosives (30 percent strength) ... pounds per ton	0.7065
Total power ... kw.-hr. per ton	6.88
Other supplies, percent of total power and supplies	42.24
Power and supplies, percent of total cost	37.07

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